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Oceans and the law of the sea

Oceans and the law of the sea*

Report of the Secretary-General

Summary

In paragraph 339 of its resolution 71/257, as reiterated in paragraph 354 of resolution 72/73, the General Assembly decided that the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea would focus its discussions at its nineteenth meeting on the theme "Anthropogenic underwater noise". The present report was prepared pursuant to paragraph 366 of Assembly resolution 72/73, with a view to facilitating discussions on the topic of focus. It is being submitted to the Assembly for its consideration and to the States parties to the United Nations Convention on the Law of the Sea, pursuant to article 319 of the Convention.

* Owing to restrictions on the length of Secretariat reports, the present report includes a limited number of footnotes. The advance, unedited version, available on the website of the Division for Ocean Affairs and the Law of the Sea (www.un.org/depts/los/doalos_activities/about_doalos.htm), includes all footnotes.

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I. Introduction

1. The marine environment is subject to a wide array of human-made noise. Many human activities with socioeconomic significance introduce sound into the marine environment, either intentionally for a specific purpose, such as seismic surveys, or unintentionally as a by-product of activities such as shipping. In addition, there is a range of natural sound sources from physical and biological origins such as wind, waves, swell patterns, currents, earthquakes, precipitation and ice, as well as the sounds produced by marine animals for communication, orientation, navigation and foraging.

2. A particular sound can be noise to one receiver, if it is unwanted, and a signal to others, if it is of interest. For the purpose of the present report, the terms "sound" and "noise" are used interchangeably.

3. Anthropogenic underwater sound in the ocean increased in the last half of the past century in some regions, most likely as a result of an expansion of industrial activities in the marine environment, including shipping, oil and gas exploration and exploitation, commercial fishing and, more recently, the development of offshore renewable energy.

4. The areas that are reported to be most affected by anthropogenic underwater noise are coastal areas and areas where a higher degree of human activity takes place, including shipping lanes with high levels of traffic. However, some high-intensity sources of underwater sound, such as airguns, can be recorded over distances of several thousand kilometres. Effects may thus occur far away from the location of the source. The regions most affected include the southern North Sea, the Mid- and North Atlantic coast of the United States of America and the Canadian Pacific coast. In general, measurements are lacking and more regions may be affected. In the future, with the retreat of Arctic Sea ice and the consequent heightened level of activity, the Arctic, which was previously a relatively quiet area, is likely to be exposed to increased levels of anthropogenic noise.

5. Increased levels of sound have been shown to have a wide range of effects on many types of marine biota, including marine mammals, fish and invertebrates. Such effects include physical damage, disruption of communication among animals and displacement of animals from their preferred breeding, nursery or feeding grounds, with consequent potential effects on their breeding success and survival.

6. Although the long-term consequences of chronic noise on marine life are still largely unknown, there are increasing concerns about the long-term and cumulative effects of noise on marine biodiversity and the resulting socioeconomic impacts.

7. Anthropogenic underwater noise and its impacts have received increasing attention from various intergovernmental forums at the global and regional levels. To facilitate the discussions at the nineteenth meeting of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea, unless otherwise indicated, the present report is based on the *First Global Integrated Marine Assessment: World Ocean Assessment I*,[1] the peer-reviewed scientific studies submitted to the Division for Ocean Affairs and the Law of the Sea of the Office of Legal Affairs pursuant to a number of General Assembly resolutions on oceans and

[1] United Nations, *First Global Integrated Marine Assessment: World Ocean Assessment I* (Cambridge University Press, 2017).

the law of the sea,[2] lists of which are available on the website of the Division,[3] other peer-reviewed reports and scientific and technical publications,[4] as well as the contributions received from States and relevant organizations and bodies upon the Secretary-General's invitation.[5] The full text of these contributions is available on the website of the Division.[6]

II. Nature and sources of anthropogenic underwater noise

A. Physics of sound in seawater

8. Sound is a form of energy created when particles in an elastic medium are displaced by an external force and oscillate. The units for measuring the frequency of these oscillations are Hertz (Hz). Sound levels or sound pressure levels are referred to as decibels (dB).[7] There are different measurements and units to quantify the amplitude and energy of the sound pressure level and efforts are ongoing to define acoustical terms in a more precise way. In addition to pressure, sound also has a particle motion component which relates to the displacement, velocity and acceleration of the particles in the sound wave. Most marine mammals are sensitive to sound pressure. Fish and invertebrates are principally sensitive to particle motion, although some fish also detect sound pressure.

9. In seawater, sound travels at a speed of approximately 1,500 metres per second, which is almost five times faster than the speed of sound in air. The speed depends on the physical properties of the seawater, including its temperature, pressure and salinity, causing the propagation of sound to be subject to refraction and reflection with changing conditions, which changes its path and can have sound channelling effects. In such sound channels, sound can propagate without losing significant energy.

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[2] See General Assembly resolutions 61/222, para. 107, 62/215, para. 120, 64/71, para. 162, and 71/257, para. 266.

[3] See www.un.org/depts/los/general_assembly/noise/noise.htm. A synthesis of those studies was prepared for the Division by a consultant, Frank Thomsen.

[4] In particular, the Convention on Biological Diversity Secretariat, Scientific Synthesis of the Impacts of Underwater Noise on Marine and Coastal Biodiversity and Habitats (UNEP/CBD/SBSTTA/20/INF/8).

[5] Contributions were received from the Governments of Malaysia, Mauritius and the United States of America, as well as from the European Union, which included the separate contributions of Belgium, Estonia, Finland, France, Lithuania, Malta, Netherlands, Poland and Sweden. The following intergovernmental organizations also sent contributions: the Commission for the Protection of the Marine Environment of the North-East Atlantic, the General Fisheries Commission for the Mediterranean, the Food and Agriculture Organization of the United Nations, the Baltic Marine Environment Protection Commission, the International Hydrographic Organization, the International Maritime Organization, the secretariat of the International Whaling Commission and the secretariat of the Pacific Regional Environment Programme. The secretariat of the Convention on Biological Diversity and the International Union for Conservation of Nature also made contributions.

[6] www.un.org/depts/los/general_assembly/general_assembly_reports.htm.

[7] Underwater, decibel levels are different from above water. Sound pressure levels in air are referenced to 20 µPa, while underwater they are referenced to 1 µPa (see UNEP/CBD/SBSTTA/20/INF/8). In order to compare decibel levels in air with decibel levels underwater, 25.5 dB must be added to the in-air values, together with an additional 36 dB owing to the higher acoustic impedance of water compared with that of air. Thus 100 dB re 20 µPa in air is equivalent to 161.5 dB re 1 µPa underwater.

10. With increased distance from the sound source, acoustic power will generally be lost through geometrical spreading, absorption and scattering. Transmission losses and sound propagation can be very complex and differ depending on water depths, seabed topography and the characteristics of the water column. Absorption losses can be significant for high frequencies but are negligible for low frequencies below 1 kHz. Therefore, lower frequencies carry much further underwater than higher ones. Depending on conditions, some low-frequency sounds can travel thousands of kilometres and even cross several ocean basins, especially when "trapped" in a sound channel.

11. The distinctive properties of underwater sound in terms of range and speed of signal transmission and the limitations of other senses such as vision, touch, taste and smell in the marine environment make sound the preferred sensory medium for many marine animals.

B. Types of anthropogenic underwater sound

12. At the source, two main types of anthropogenic underwater sound can be distinguished as follows: impulsive or transient; and non-impulsive or continuous.

13. Impulsive sounds are characterized by a short duration, high sound intensity with a large change in amplitude over a short time. They may either be a single event or repetitive. Examples of impulsive sounds are those produced by explosions, airguns, sonar and piledriving. At greater distance from the source, low-frequency impulsive sounds can "smear", owing to various propagation effects and become non-impulsive. Impulsive sounds have a high potential to cause physiological damage, particularly on hearing.

14. Non-impulsive or continuous sounds are generally of lower intensity. Examples of non-impulsive sounds are those produced by ship propellers, industrial activities (e.g. drilling and dredging) and renewable energy operations.

C. Sources of anthropogenic underwater sound

15. There are a number of sources which introduce sound into the marine environment intentionally or unintentionally. While some sources are global in significance, such as commercial shipping, others may have a more regional significance, for example piledriving in Europe, where the installation of marine renewable energy devices has increased. Below is a summary of the main anthropogenic underwater sources; an overview of the main physical properties of those sources is provided in the annex.

16. **Underwater explosions.** These are one of the strongest point sources of anthropogenic sound. There are two types of man-made explosions in or over the ocean: nuclear and chemical. While nuclear devices were tested regularly in the ocean before the adoption of the Comprehensive Nuclear-Test-Ban Treaty, no such tests appear to have been conducted since 1996. Chemical explosives are used for several purposes underwater, including seismic surveying, construction, removal of structures, ship shock trials and military warfare and to deter marine mammals, catch fish or mine coral. The sounds from an explosion propagate equally in all directions and are detectable on a regional scale, although in some cases a single shot has been detected over several ocean basins.

17. **Seismic profiling.** Seismic profiling uses high-intensity sound to image the earth's crust. It is the primary technique used in oil and gas exploration and is also used to gather information on crustal structure. A range of sound sources may be used for that purpose, including airguns, sparkers, boomers, pingers and compressed high-intensity radiated pulse (CHIRP) sonar. The main sound-producing elements used in oil exploration are airgun arrays, the power of which has generally increased during the past decades, as oil and gas exploration has moved into deeper waters. A study in the North Atlantic suggests that sound from airguns along the continental margins propagates into the deep ocean and is a significant component of low-frequency noise. In some instances, sound signals from seismic airgun surveys can be received thousands of kilometres away from the source, through a sound channel. Sparkers and boomers are high-frequency devices used to determine shallow features in sediments. Their signals may penetrate several hundred or tens of metres of sediments, in the case of sparkers and boomers, respectively. CHIRP sonars also produce sound in the upper frequency range.

18. **Sonars.** Sonar systems intentionally create acoustic energy to gather information about objects within the water column, on the seabed or within the sediment. Most sonars operate at one frequency of sound but generate other unwanted frequencies, which may have wider effects than the main frequency used, especially if at low frequencies, which propagate further underwater. Military sonars are used for target detection, localization and classification, and generally cover a broader frequency range with higher source levels than civilian sonars, which tend to use mid- and high frequencies. They are operated during both training exercises and combat operations. Since more time is spent in training than in combat, this may be the primary context in which marine mammals are exposed to military sonar. Commercial sonars are designed mainly for fish finding, depth sounding and sub-bottom profiling. These sonars generally produce sound at lower source levels than military sonars, but may be more pervasive owing to the substantial number of commercial vessels equipped with sonar.

19. **Vessels.** A significant proportion of underwater sound in the ocean is caused by vessels. The propulsion systems of large (e.g., container/cargo ships, supertankers, cruise liners) and mid-sized (e.g., support and supply ships, many research vessels) vessels are a dominant source of underwater sound at low frequencies. Cavitation at the propeller blade tips has been found to be a significant source of noise across all frequencies. Additional sources of ship noise include rotational machinery, which produces tones, and reciprocating machines which produce sharp pulses at a constant repetition rate. Large vessels dominate low-frequency background noise in many marine environments worldwide. Ice-breaking ships are a source of sound in polar regions through the use of bubbler systems and high-speed propelling to push floating ice away. Smaller vessels (e.g., recreational craft, jet skis, speed boats, operational work boats) produce sound that is generally highest in the mid-frequency range and at moderate source levels, although this depends on speed. Owing to the generally higher acoustic frequency and near-shore operation, noise from smaller vessels does not extend far from the source.

20. **Industrial activities.** Examples of industrial activities that contribute to underwater noise include: coastal power plants; piledriving; dredging; drilling; tunnel boring; the construction and operation of wind farms; hydrocarbon activities; cable laying; and canal lock operations. These activities generally produce sound that has the most energy at low frequencies (i.e., below 1 kHz). Dredging, which is undertaken to maintain shipping lanes, extract geological resources such as sand and gravel and to route seafloor pipelines, emits continuous broadband sound during operations,

mostly in the lower frequencies. The environmental impacts of near-shore mining, including from underwater noise, are similar to those of dredging operations. Hydrocarbon activities that generate sound include drilling, offshore structure emplacement and production. Drilling can be done from natural or man-made islands, platforms and drilling vessels (semi-submersibles and drilling ships). Noise levels from natural or man-made islands have been reported to be moderate, while noise from fixed drilling platforms is slightly lower, and drilling from drill-ships produces the highest levels. Deepwater drilling and production have the potential to generate greater noise than shallow-water production, owing to the use of drill ships and floating production facilities. The sound levels of piledriving, which is used for harbour works, bridge construction and oil and gas platform installations and in the construction of offshore wind farm foundations, can vary depending on the diameter of the pile and the method of pile driving (impact or vibropiling). Offshore wind farm construction undertaken using impact piledriving creates low-frequency noise at relatively high source levels, while their operation produces much lower source levels, with additional noise generated by maintenance and repair work. There is currently limited information available on the acoustic characteristics of offshore tidal and wave energy turbines.

21. **Acoustic deterrent and harassment devices.** Acoustic deterrent devices are used to discourage marine mammals from approaching fishing gear, including for the purpose of reducing by-catch. Fish deterrent devices are used mainly in coastal or riverine habitats to temporarily displace fish from areas of potential harm, for example, by guiding fish away from water intakes of power plants. There is considerable variation between devices in terms of frequency range, depending on the fish species targeted. Acoustic harassment devices emit tone pulses or pulsed frequency sweeps at high source levels to keep seals and sea lions away from aquaculture facilities or fishing equipment. Some fishing operations employ explosive charges, such as "seal bombs", to prevent seals and sea lions from competing for fish, or to scare dolphins. Seal bombs are also used to deter pinnipeds from occupying recreational boat and dock areas, inhabiting public swimming areas and foraging on endangered salmon species.

22. **Other sources.** Other sources of sound include marine scientific research, which may produce sound at mid- to high frequency and at high source levels. In addition, acoustic telemetry is used for: underwater communications; remote vehicle command and control; diver communications; underwater monitoring and data logging; trawl net monitoring; and other industrial and research applications requiring underwater wireless communications. Long-range systems can operate over distances of up to 10 kilometres using frequencies of 7–45 kHz at high source levels.

III. Environmental and socioeconomic aspects

A. Impacts on marine species and the marine environment

23. Many anthropogenic sounds fall within the hearing range of marine species and can therefore impact such species in different ways. The impact of sound on a marine species depends on a range of factors, including the sensitivity of the species to sound; the frequency, duration and intensity of the sound; and distance from the sound source.

1. General effects on marine species

24. A wide range of effects of increased levels of underwater anthropogenic sound on marine species has been documented, both in laboratory and field conditions. These range from no adverse impacts, to mild or significant behavioural responses, to physical injury or death.

25. Since sound is used by marine species for a wide variety of purposes and plays a key role in communication, navigation, orientation, feeding and the detection of predators, the introduction of anthropogenic sound into the marine environment may interfere with these functions. The masking of acoustic signals may greatly reduce the range at or extent to which relevant sounds can be transmitted or perceived by marine species, or cover them completely. Masking can have serious consequences, for example if acoustic signals used by individuals to keep in contact with one another are affected.

26. Various categories of behavioural change due to noise exposure have been observed. These include leaving or avoiding the area around the source of the sound, changes in feeding patterns and changes in social behaviour and movement. Lack of reaction does not necessarily correlate to a lack of negative impact, as some species may be conserving energy, protecting their territory or may not react to noise at intensity levels which may cause damage over the long-term but not in the short term.

27. In some cases, exposure to noise can result in physical damage to marine animals, including temporary or permanent hearing loss. Physiological effects and effects on hearing are related to the dose of exposure, which involves the duration of impact as well as the intensity of the sound. Physiological impacts and hearing impairment can potentially occur at received levels that do not cause a behavioural response, for example when animals are exposed to noise for a long time. In extreme cases, exposure can result in death.

2. Effects by taxon

28. Although research on the impacts of anthropogenic underwater sound on marine species is still in its infancy, negative impacts have been identified for at least 55 marine species.

29. **Marine mammals.** Marine mammals use sound as a primary means of underwater communication and sensing. They have a wide bandwidth of hearing, which ranges from well below 1 kHz to over 180 kHz. The masking of marine mammals' sounds, for example as a result of increased background noise from shipping, can lead to a decrease in communication space (the volume of space surrounding an individual within which acoustic communication can be expected to occur). Sound can also trigger behavioural responses in marine mammals, such as avoidance of the noise area, leading to displacement (short- and long-term), changes in communication behaviour (change in pattern but also alterations of the sounds), startle behaviours, changes in surface patterns and changes in diving behaviour. Studies have also shown physical damage and physiological responses to anthropogenic underwater sound, including temporary and long-term hearing loss and strandings. Incidents of whale strandings have been associated with naval sonar exercises which triggered an extreme behavioural response such as repetitive dives, causing decompression sickness.

30. **Fish.** Fish possess two sensory systems for acoustic and water motion detection, with species being sensitive principally to particle motion and only a few groups able

also to perceive sound pressure. Fish utilize sound for navigation and selection of habitat, mating, predator avoidance and prey detection and communication. For example, some larval reef fish rely on sound to locate their reef habitat. Although less is known regarding the impacts of underwater sound on fish, a number of studies have identified impacts on some species, while other studies found no impacts. Anthropogenic sound has been demonstrated to cause behavioural change, including avoidance, vertical or horizontal movement and school tightening. Impulsive sound from airguns may also lead to decreased egg viability, increased embryonic mortality or decreased larval growth in eggs and larvae. Some evidence exists of physical and physiological effects, including increased stress indicators in response to noise and physical damage to tissue caused by noise, such as by causing swim bladders to tear or rupture, in response to high-intensity impulsive sounds.

31. **Marine invertebrates and other species.** Most marine invertebrates that are sensitive to sound perceive particle motion at low frequencies. Some species, such as species of barnacles, amphipods, shrimps, crabs, lobsters, sea urchins and squid are also capable of emitting sounds, possibly for communication with conspecifics. Marine turtles are also sensitive to low-frequency sounds. Research into the effects of anthropogenic underwater sound on marine invertebrates and other species is still limited and, to date, primarily confined to laboratory experiments. Research indicates that certain species, such as some turtles, crustaceans and cephalopods, exhibit behavioural responses or stress reactions to sound, while other species do not. Prolonged exposure to increased background noise can affect feeding, growth and development in some invertebrates. Physical and physiological damage may also occur, including injury to hearing organs and changes in blood composition. There is some evidence that species such as giant squid and other cephalopods may be susceptible to physical damage from impulsive sounds. Studies on the impacts of underwater sound on seabirds are still limited. There is evidence, however, that some species, such as cormorants, hear relatively well underwater. Such species could be impacted by sounds.

3. Broader ecosystem impacts and cumulative effects

32. Although some species are more susceptible to anthropogenic underwater sound than others, the actual impact on the marine ecosystem may be broader, as the weakening or elimination of a particular species from an ecosystem could have impacts on associated or dependent species and affect the overall balance of the ecosystem. For example, physiological and physical effects on invertebrates and fish can lead to mortality in animal groups that are prey to other animals, and behavioural reactions of fish due to noise can lead to displacement and affect the feeding behaviour of marine mammals.

33. The impacts of underwater sound on specific species have, to a large extent, been studied in controlled settings. However, the actual impact on marine species and ecosystems will depend on the cumulative impacts of multiple stressors, including other forms of marine pollution, ocean acidification, climate change, overexploitation, by-catch and alien invasive species. For example, global changes in ocean parameters such as temperature and acidity are likely to have consequences for underwater noise levels through changes in sound absorption. Only a few studies have addressed anthropogenic underwater sound in the context of such cumulative pressures.

B. Socioeconomic aspects

34. Many of the activities that introduce sound into the marine environment, either intentionally or not, are important components of efforts to achieve the 2030 Agenda for Sustainable Development (General Assembly resolution 70/1), in particular Sustainable Development Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development, as well as other international commitments related to sustainable development.

35. There is growing concern, however, that anthropogenic underwater noise might potentially cause negative socioeconomic consequences either through a ripple effect, as many human activities depend on marine species, or by affecting humans directly. While research on such consequences is still limited, available studies show that anthropogenic underwater noise may cause economic loss in certain circumstances. For example, population-level consequences resulting from changes in reproduction and spawning or displacement of fish may lead to decline in catch rates in some commercially important species, thus affecting revenues from fisheries negatively. Displacement, relocation, stranding and possible long-term population reduction of marine mammals may also affect tourism industries such as whale watching.

36. Some social groups may be more affected by noise-induced impacts on marine life or by underwater sound directly. For example, displacement and redistribution of fishes and marine mammals may affect artisanal fishing and subsistence hunting by local and indigenous communities, thus impacting their livelihood and traditional and cultural practices. Studies also show that the hearing of divers may be impaired by exposure to ambient underwater noise.

37. While sound in the ocean may be unavoidable, mitigation measures can have environmental and socioeconomic benefits. The development of new technologies, such as noise-quieting technologies, tools and practices for understanding and managing the impacts of underwater noise, can also provide market opportunities in addition to reduced environmental impacts. For example, reducing ambient noise from ships by reducing their speed could contribute to limiting carbon dioxide emissions from ships and mitigating climate change, as well as avoiding wait time off ports before docking.

IV. Current activities and further needs with regard to cooperation and coordination in addressing anthropogenic underwater noise

A. Legal and policy frameworks

1. Global level

38. The United Nations Convention on the Law of the Sea does not specifically mention noise pollution. However, since sound is a form of energy, its introduction into the marine environment, if it results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities (art. 1), is considered by some a form of pollution of the marine environment under the Convention. If it is deemed to be pollution, States would be required to take all measures necessary to prevent, reduce and control pollution of the marine environment (arts. 194 and 196)

from anthropogenic underwater noise, including those necessary to protect and preserve rare or fragile ecosystems, as well as the habitat of depleted, threatened or endangered species and other forms of marine life.

39. In addition, of particular relevance in the context of activities introducing sound into the marine environment are the provisions of the United Nations Convention on the Law of the Sea requiring States to adopt laws and regulations concerning pollution from vessels, land-based sources, seabed activities, activities in the Area and from or through the atmosphere (arts. 196, 207, 208, 209, 212) (see para. 37) and to enforce such laws and regulations. These laws and regulations must either take into account internationally agreed rules, standards and recommended practices and procedures (arts. 207 and 212) (e.g., in the case of land-based pollution and pollution from or through the atmosphere), be no less effective than the international rules, regulations, standards and recommended practices and procedures (art. 208) (e.g., in the case of seabed activities and activities in the Area) or at least have the same effect as that of generally accepted international rules and standards (art. 211) (e.g. in the case of pollution from vessels). In addition, each State shall ensure, by the adoption of appropriate measures not impairing operations or operational capabilities of warship, naval auxiliary, other vessels or aircraft owned or operated by it and used only on government non-commercial service, that such vessels or aircraft act in a manner consistent, so far as is reasonable and practicable, with the Convention (art. 236). States shall also take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from the use of technologies under their jurisdiction or control which may cause significant and harmful changes thereto (art. 196). The obligations relating to monitoring and environmental assessment also apply. Given the transboundary nature of noise pollution, States must also be in compliance with the obligations to ensure that activities under their jurisdiction or control are so conducted as not to cause damage by pollution to other States and their environment or beyond the areas where they exercise sovereign rights (art. 194).

40. Also to be borne in mind when addressing anthropogenic underwater noise are the provisions of the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, requiring States to, inter alia, assess the impacts of fishing, other human activities and environmental factors on target stocks and species belonging to the same ecosystem or associated with or dependent upon the target stocks; minimize pollution; and protect biodiversity (art. 5 (d), (f) and (g)).

41. Beyond these general provisions, most of the international rules, standards and recommended practices and procedures to address anthropogenic underwater sound are of a policy and non-legally binding nature. While research gaps still exist (see para. 49), a precautionary approach is called for, in accordance with principle 15 of the Rio Declaration on Environment and Development. Besides the calls by the General Assembly for further studies and research, target 14.1 of Sustainable Development Goal 14, by 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution, also applies to noise pollution. The declaration "Our ocean, our future: call for action", adopted at the United Nations Conference to Support the Implementation of Sustainable Development Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development ("Ocean Conference") in June 2017, includes a specific reference to addressing underwater noise (see General Assembly resolution 71/312, para. 13 (g)).

42. Other measures, which have focused on increasing scientific knowledge of the issues, prevention of noise pollution at the source and mitigation of the impacts, include those adopted in the context of the work of the International Maritime Organization (IMO) with regard to shipping, and the Food and Agriculture Organization of the United Nations (FAO) with regard to fishing vessels. Noise from dredging activities has been discussed in the context of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972) and its Protocol. The Convention on Biological Diversity, the Convention on the Conservation of Migratory Species of Wild Animals and the International Whaling Commission have considered the impacts of underwater noise from various sources on marine biodiversity or specific marine species, as well as mitigation measures. The majority of the measures adopted in those contexts have emphasized the need for further research and for a precautionary approach.

43. Overall, the measures concerned remain largely sectoral, focused on certain noise-emitting activities or on certain affected species. Challenges in regulating sound-producing activities at the global level, besides research gaps, include the absence of intergovernmental forums for certain sound-producing activities; a lack of common internationally agreed standards of acceptable noise levels and mitigation techniques; and a lack of common measurements standards. With regard to the latter, work on standardization has started and the International Organization for Standardization has adopted a number of international standards related to measurement of underwater noise radiating from ships and pile-driving, as well as terminology related to underwater acoustics. In some cases, where no global rules, standards and recommended practices and procedures exist, industry sectors, such as dredging and oil and gas producers, have issued guidance addressing underwater noise.

2. Regional level

44. Actions to address impacts of anthropogenic underwater noise through regional legal and policy frameworks appear to be limited to the waters surrounding the European Union, the North-East Atlantic, the Mediterranean and the Baltic. Measures in those regions, including in the context of the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and neighbouring Atlantic Area; the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas; the Baltic Marine Environment Protection Commission; and the Convention for the Protection of the Marine Environment of the North-East Atlantic, have included the development of strategies, roadmaps and guidance.

45. With regard to military activities, the North Atlantic Treaty Organization (NATO) has issued mitigation rules and procedures and adopted a code of conduct. While available information does not allow sufficient analysis of activities currently being undertaken with regard to fishing activities by regional fisheries management organizations and arrangements, it appears that many such organizations and arrangements have yet to address the issue of anthropogenic underwater noise.

3. National level

46. At the national level, legislation in some countries requires public entities generating noise in the marine environment to evaluate their activities for effects on protected marine life and the environment. Noise restrictions often form part of broader legislation to protect the environment or endangered species or of legislation addressing specific activities, such as energy development. While ocean noise

roadmaps and strategies have been developed in some countries, guidelines and codes of conduct seem to be the most usual form of addressing anthropogenic underwater noise. Seismic surveys and offshore construction projects are the activities most commonly addressed. Furthermore, the regulatory frameworks focus on protecting marine mammals, although some guidelines also include measures to protect seabirds and marine turtles. Several contributions note the importance of understanding the impacts of noise in order to be able to regulate them adequately, and several States promote a precautionary approach.

B. Science, data and technology

47. To fully understand the effects of anthropogenic underwater noise on the marine environment, it is essential to be able to detect, recognize and categorize sounds in the marine environment and to have sufficient biological and ecological information for each marine species. In recent years, the impact of anthropogenic underwater noise on the marine environment has been the subject of scientific investigation in certain regions. Intra- and cross-sectoral efforts have been made to collect data on noise levels and investigate the impacts on the marine environment.

48. Noise monitoring programmes have been or are being put in place in the Baltic, the Mediterranean and the North Sea, as well as in the waters off mainland France and the United States. Projects to investigate or mitigate the impacts of anthropogenic underwater noise from shipping are under way in Australia, Canada, Japan and the European Union, in particular in the Baltic Sea. The International Quiet Ocean Experiment is an international scientific programme established to promote research, observations and modelling to improve understanding of ocean soundscapes and effects of sound on marine organisms. Technical and scientific workshops and conferences on anthropogenic underwater noise have been held in the context of, inter alia: the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and neighbouring Atlantic Area; the Convention on Biological Diversity; the Convention on the Conservation of Migratory Species of Wild Animals; the Baltic Marine Environment Protection Commission; IMO; the International Whaling Commission and the Convention for the Protection of the Marine Environment of the North-East Atlantic. The outputs of these efforts include monitoring technologies, noise registries, species databases and modelling and planning tools and software.

49. Nonetheless, there are significant data and knowledge gaps in relation to anthropogenic underwater sound and its impacts on the marine environment. Most past research has focused on impulsive sounds, such as sonar, airguns and impact pile-driving, as well as on marine mammals, in particular cetaceans. Many sound sources, such as pile-driving and shipping, are not fully understood, including with regard to sound levels and fields emitted. Most of the research so far has focused on marine mammals, with very few studies on fish and invertebrates. There is also an incomplete understanding of particle motion and the sensitivity of fish and invertebrates. While a considerable effort has been made in recent years to study the behavioural response of marine life to sound, many of the studies are limited to very small sample sizes. There is also a limited understanding of the effects of multiple exposures to sound, including from diverse sources, as well as the way in which multiple pressures interact in the marine environment. Further research is also required to monitor trends in noise levels over time, including for the purpose of establishing baselines. Measurements, in general, are lacking. In addition, the

socioeconomic consequences of noise-induced impacts on marine populations have not been sufficiently considered to date.

50. The lack of data on both noise and marine species is a key hindrance to modelling the impacts of anthropogenic underwater sound at the population and ecosystem scales. It also limits the extent to which effective management measures can be developed. This is especially true for certain regions, including in western Africa, the Pacific Islands region and South-East Asia, where data deficits concerning the abundance and distribution of marine mammals may hamper efforts to protect them, including from sound. To remedy this situation, there is a need to establish long-term monitoring schemes, incorporating acoustic measurement into global ocean monitoring systems, and to foster international cooperation in the planning and execution of research programmes.

51. Several technologies aimed at reducing sound levels or mitigating noise impacts have been developed in recent years. In general, mitigating noise that is the by-product of activities is easier than when sound is deliberately emitted. Dampening materials have been developed to reduce noise from pile-driving, marine vibroseis is being explored as an alternative to seismic surveys, and ship-quieting technologies, primarily relating to vessel design, are being applied to existing and new vessels. Marine scientific research vessels are normally constructed to emit as little sound as possible, given that noise may interfere with measurements and equipment.

52. Overviews of a wide range of noise mitigation technologies are included in documents from: the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and neighbouring Atlantic Area; the Baltic Marine Environment Protection Commission; the Convention for the Protection of the Marine Environment of the North-East Atlantic; and in national and international guidelines dealing with sound-generating activities at sea. The effectiveness and impact on the marine environment of some of the new technologies and measures needs to be researched further.

C. Management measures

1. Environmental impact assessments

53. Understanding the environmental impacts of underwater sound is critical for the development and implementation of adequate mitigation measures. At present, the effects of sound on marine mammals are addressed in environmental impact assessment processes in the European Union and the United States for some activities, such as the installation of offshore wind farms and seismic surveys. Effects on fish are much less covered compared to mammals. While some global and regional forums have called for the consideration of the impacts of underwater noise on marine life in environmental impact assessments, including cumulative impacts in some cases, this is yet to be considered by some forums with a mandate over activities or sectors with a potential significant contribution to underwater noise. In addition, the lack of sufficient baseline data on the distribution and abundance of marine life in some areas, as well as how the effects of a planned activity act in conjunction with other activities, present limits to the effectiveness of environmental impact assessments.

2. Integrated management and area-based management tools

54. Integrated management of oceans and seas is a critical underpinning of sustainable development. It is cross-sectoral and involves all relevant stakeholders.

Area-based management tools, including marine protected areas and marine spatial planning, form part of integrated management. Given the variety of sources of sound in the ocean and the potential interaction of sound with other pressures, integrated management could be beneficial in addressing anthropogenic underwater noise. While the inherent difficulties in assessing the effects of sound on marine life present challenges for management efforts, anthropogenic underwater noise is increasingly considered in management strategies.

55. A sectoral approach to noise management remains prevalent. However, area-based management tools, in particular marine protected areas, are increasingly used as noise mitigating measures. Further use of such tools has been recommended. Challenges exist, however, in using area-based management tools to address noise impacts, including difficulties in identifying animal hotspots due to limited data, the fact that many marine mammals and fish are highly migratory and difficulties in determining the size of important habitats for species that communicate over large areas.

3. Other measures

56. Efforts to develop measures, best practices and best available techniques to mitigate the impacts of anthropogenic underwater noise are taking place in several sectors at the national, regional and global levels. A review of the content of various guidelines reveals that there are many measures, practices and techniques that can be applied to a wide range of activities to mitigate the impacts of anthropogenic underwater noise.

57. Pre-activity surveys of an area, gathering of baseline data or full environmental impact assessments are recommended in the majority of guidelines. The implementation of spatio-temporal restrictions, for example to avoid spawning, calving, breeding or migration periods or sensitive, protected or enclosed areas, is a recommended mitigation measure for most human activities covered by the guidelines surveyed. Similarly, the use of exclusion zones coupled with visual detection, for example marine mammal observers, is commonly recommended for many activities, in particular those that purposely introduce sound into the marine environment, including sonar, sound exposure experiments and seismic surveys. The use of soft start or ramp-up protocols to allow marine species to leave the area, or acoustic deterrent devices to keep them out, are other commonly used measures for such activities. The use of trained on-board observers sometimes forms part of codes of practice.

58. While few guidelines have set specific thresholds for emitted or received sound levels, several emphasize the importance of using the lowest practicable level when sound is purposely introduced into the environment. For example, the 2006 NATO Undersea Research Centre Human Diver and Marine Mammal Risk Mitigation Rules and Procedures (NURC-SP-2006-008) recommend that the sound level at reception point should not exceed 160–186 dB re 1 micropascal (μPa) — depending on frequency — if mysticetes, odontocetes or pinnipeds are present, and 160–177 dB re 1μPa or 154 dB re 1μPa for alerted military divers and recreational divers, respectively. Noise criteria have been developed in some countries to describe received levels of noise that should not be exceeded in order not to cause harm to marine life. Such criteria have been developed and applied both for behavioural response and injury, and include those developed by the United States National Marine Fisheries Service concerning marine mammals and by some European Union member States for impact pile-driving, as well as other scientific marine mammal noise exposure criteria applied as de facto noise criteria in environmental assessments around the globe. However, the development of adequate noise criteria and restrictions depends on further research and understanding concerning hearing

sensitivity of more animal groups, the appropriate metrics to use based on functional hearing groups and the impacts of noise on marine species.

59. With regard to vessels, the design stage is widely regarded as the best opportunity for noise reduction. Changes to vessel design, in particular to hulls and propellers, or the use of lightweight or dampening materials, are commonly recommended measures. For existing vessels, operational changes such as speed reduction, modification of shipping routes and regular vessel maintenance to reduce drag and cavitation are recommended.

60. At the national level, several States, in all regions, have developed guidelines for responsible nature tourism, including the watching of whales, seals, dolphins and other marine life.

61. While many of the guidelines cover general measures that could be implemented or technologies that could be used, few are concerned with the practical implementation of the recommended measures and the necessary protocols and systems to ensure their effectiveness.

D. Cooperation and coordination, including for capacity-building

62. Anthropogenic underwater noise is a pervasive global issue, with countless sources of sound, impacted species and affected ecosystems. Cooperation and coordination, within and across different sectors, is vital to building capacity, further developing scientific understanding of anthropogenic underwater sound and addressing its impacts in a cross-sectoral and integrated manner.

63. Cooperation and coordination within and across different sectors representing sound-generating activities (mining, oil and gas exploitation, military, shipping, fisheries, marine renewable energy, etc.) or impacted sectors (fisheries, tourism, environment, etc.) can facilitate awareness-raising, the sharing of information on the sources and impacts of anthropogenic underwater noise and the development and sharing of best practices for minimizing such impacts and addressing cumulative impacts. Since stakeholders may be dealing with very similar issues in different regions of the world, such cooperation could also provide cost benefits.

64. International cooperation has mostly taken the form of scientific workshops and expert groups, as well as conferences. These events have built capacity through exchanges between experts working in different disciplines, including acousticians and biologists, as well as fostered greater communication between different stakeholders, including industry and regulators.

65. Besides information-sharing, the output of such events has included guidance and guidelines, including mitigation measures, covering certain sound-emitting activities, such as shipping, offshore wind farm development, recreational fisheries and dredging or specific species.

66. The need to compile toolboxes developed in different countries and tailor them to countries, taking into account their socioeconomic and cultural contexts, as well as available scientific and technical capabilities, has been noted. Other suggestions have included increasing awareness of environmental impact assessments and related guidelines in countries and regions where relevant legislations and/or guidelines addressing the issue are not available; engaging industries as well as non-governmental and other civil society organizations to assist developing countries in building local capacity to understand, prevent and control anthropogenic noise;

requiring industries to involve academic or research institutions in their processes addressing noise; encouraging the development of academic courses in the field; and further developing best management practices.

67. In the light of the rapidly growing body of scientific knowledge regarding anthropogenic underwater sound, the sharing of information and data between scientists through scientific or academic networks is also critical. Information on additional peer-reviewed scientific studies may also be submitted to the Division, in accordance with relevant General Assembly resolutions. Some research projects have specifically included a capacity-building aspect.

68. Given their global outreach potential, web portals and webinars have proved as a useful tool for sharing knowledge and raising awareness. One example is Discovery of Sound in the Sea, a publicly funded website dealing with the science of sound.

69. Financing opportunities are available from various institutions for work on anthropogenic underwater sound. These include: the Ocean Acoustics programme of the United States Office of Naval Research, which supports basic research addressing fundamental understandings of the physics relating to underwater sound; the Acoustics Program of the United States National Oceanic and Atmospheric Administration Fisheries Office of Science and Technology, which funds research on examining the potential impacts of anthropogenic sound on marine animals; the European Metrology Programme for Innovation and Research, which has funded capacity-building projects aimed at developing metrological capacity in underwater acoustics; and the Exploration and Production Sound and Marine Life Joint Industry Programme of the International Association of Oil and Gas Producers, which supports research to increase understanding of the effect on marine life of sound generated by oil and gas exploration and production activity.

70. In order to address anthropogenic underwater noise, the development and transfer of new alternative quieter technologies (see para. 51) will be essential, including for the benefit of developing countries, in accordance with Part XIV of the United Nations Convention on the Law of the Sea and taking into account the Criteria and Guidelines on the Transfer of Marine Technology of the Intergovernmental Oceanographic Commission. Sustainable Development Goal 14, in particular its target 14.a, and Sustainable Development Goal 17, in particular its targets 17.6 to 17.8, also provide an impetus in that regard.

71. Intergovernmental organizations competent to work on specific issues may serve as important forums for strengthening cooperation and coordination. These include IMO, FAO, the Convention on Biological Diversity, the Convention on the Conservation of Migratory Species of Wild Animals and the International Whaling Commission at the global level; and the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and neighbouring Atlantic Area, the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas, the European Union, NATO, and the Convention for the Protection of the Marine Environment of the North-East Atlantic at the regional level (see section III.A above). Industry groups, such as the World Organization of Dredging Associations and the International Association of Oil and Gas Producers, as well as civil society organizations such as OceanCare, have also organized events aimed at sharing information on anthropogenic underwater noise.

72. The General Assembly, which is the competent global institution to undertake an annual review of developments in ocean affairs and the law of the sea, provides a forum for cross-sectoral cooperation and coordination. In that context, the Informal

Consultative Process can provide a platform to enhance cross-sectoral sharing of information, including on recent science, best practices and regulatory approaches. The Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects, could also play an important role in the distribution of relevant information and fostering the science-policy interface in relation to anthropogenic underwater noise through its second global integrated marine assessment.

73. UN-Oceans, the inter-agency mechanism that seeks to enhance the coordination, coherence and effectiveness of competent organizations of the United Nations system and the International Seabed Authority, could also facilitate the exchange of information regarding anthropogenic underwater noise among its participating members, including on policy and legal developments. A number of UN-Oceans members are already active on this topic, as shown throughout the present report.

74. Cross-sectoral cooperation could also be implemented in the context of multi-stakeholder partnerships. In this regard, commitments relating to ocean noise were undertaken during the Ocean Conference, held in June 2017, including by the Government of the Netherlands, OceanCare, the Wildlife Conservation Society, the Convention on the Conservation of Migratory Species of Wild Animals, the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and neighbouring Atlantic Area and the World Ocean Council.

V. Conclusions

75. Most human activities taking place in the ocean generate sound, either intentionally or as a by-product, and many of these activities provide socioeconomic, security and environmental benefits. At the same time, increased reliance on oceans for human activities has brought to our ocean a wide range of sounds, both impulsive and continuous, and increased noise levels.

76. In many instances, anthropogenic underwater noise is pervasive: whereas coastal areas and areas where more human activity takes place, such as shipping lanes, are most affected, some high-intensity sources of underwater sound, such as airguns, can be recorded over several thousand kilometres, including in areas with little human activity, thus making the effects of sound on marine life an issue of global significance.

77. Research has demonstrated that several marine species, including marine mammals, fish and invertebrates, can be affected by increased levels of sound, resulting in effects such as behavioural changes and physical and physiological effects. The people that rely on these species for livelihood could also be affected.

78. Addressing, in an effective manner, anthropogenic underwater noise will require raising awareness of the issue as well as filling in a number of research gaps to better understand the properties and propagation of sound in the marine environment and the way in which marine life is affected. This will require, inter alia, gathering baseline data, conducting further research on species other than marine mammals such as fish and invertebrates, modelling population and ecosystem-level consequences and further studying the interaction of noise with other pressures to better assess cumulative impacts.

79. The application of a precautionary approach has been called for at both global and regional levels and efforts have been undertaken to address sound at the source,

for example by promoting the development of noise-quieting technologies and measures, or to mitigate its impacts by encouraging mitigation measures such as environmental impact assessments and the use of area-based management tools, including the establishment of marine protected areas. Best practices are being identified, taking into account the need to balance socioeconomic activities with the protection and preservation of the marine environment.

80. International cooperation and coordination are essential components of efforts to address anthropogenic underwater noise and its impacts, in particular in view of the potential transboundary impacts. Cross-sectoral cooperation is also required to address cumulative impacts. This includes cooperation, at all levels, including to build or further strengthen scientific knowledge, capacity and mitigation approaches. Partnerships between States, industry, civil society and international organizations would also be beneficial, including in the context of assistance to developing countries to address capacity and technological challenges. At the global level, the General Assembly, including through the Informal Consultative Process, is well placed to foster greater international cooperation and coordination and stimulate further mitigation action, in support of the implementation of the United Nations Convention on the Law of the Sea, as well as the achievement of the commitments in the 2030 Agenda for Sustainable Development, in particular Sustainable Development Goal 14 and the declaration "Our ocean, our future: call for action".

Annex

Overview of main sources of anthropogenic underwater noise

Sector	*Sound source*	*Sound type*	*Source level (dB re 1 µPa at 1 metre)*	*Main energy (kHz)*
Commercial shipping				
Medium-sized ships 50–100 m	Propeller/cavitation	Continuous	165–180[a]	<1
Large vessels (e.g. supertankers)	Propeller/cavitation	Continuous	180–219[a]	<0.2
Resource exploration and exploitation				
Oil and gas	Seismic airgun	Impulsive	220–262[c]	0.05–0.1
	Drilling	Continuous	124–190[a]	0.1–1
Renewable energy	Impact pile-driving	Impulsive	220–257[c]	0.1–2
	Operational wind farm	Continuous	144	<0.5
Navy				
	Low frequency sonar	Impulsive	240[b]	0.1–0.5
	Mid-frequency sonar	Impulsive	223–235[b]	2.8–8.2
	Explosions (e.g. ship shock trials, exercises)	Impulsive	272–287[a]	0.006–0.02
Fishing				
	Propeller/cavitation	Continuous	160–198[a]	<1–10
	Deterrent/harassment device	Impulsive	132–200[b]	5–30
	Sonar (echo sounder)	Impulsive	185–210[b]	200–260
Dredging	Propeller/cavitation, cutting, pumping, grabbing, digging	Mainly continuous	163–188[a]	0.1–0.5
Marine scientific research (e.g., research vessel)	Propeller/cavitation	Continuous	165–180[a]	<1
Recreational activities (e.g., recreational craft/ speedboat)	Propeller/cavitation	Continuous	160–175[a]	1–10
Tourism (e.g., whale and dolphin watching and cruise ships) — vessels <50–>100 m	Propeller/cavitation	Continuous	160–190[a]	<0.2–10
Harbour construction	Impact piledriving (e.g. sheet piling)	Impulsive	200[b]	0.1–0.5

[a] Sound pressure level.
[b] Peak sound pressure level.
[c] Peak-to-peak sound pressure level.